IC 8918

Bureau of Mines Information Circular/1983

A Guide to Geologic Features in Coal Mines in the Northern Appalachian Coal Basin

By Paul W. Jeran and Jacqueline H. Jansky

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8918

A Guide to Geologic Features in Coal Mines in the Northern Appalachian Coal Basin

By Paul W. Jeran and Jacqueline H. Jansky

UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES
Robert C. Horton, Director

This publication has been cataloged as follows:

Jeran, P. W

A guide to geologic features in coal mines in the northern Appalachian Coal Basin.

(Information circular ; 8918)

Bibliography: p. 16.

Supt. of Docs. no.: I 28.27: 8918.

1. Coal mines and mining—Appalachian Region—Safety measures. 2. Coal—Geology—Appalachian Region. 3. Ground control (Mining). I. Jansky, Jacqueline H. II. Title. III. Series: Information circular (United States. Bureau of Mines) ; 8918.

~~TN295.U4~~ 622s [622.8] 82-600359

CONTENTS

ILLUSTRATIONS

LIST OF UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	m	meter
in	inch	pct	percent
ft	foot		

A GUIDE TO GEOLOGIC FEATURES IN COAL MINES IN THE NORTHERN APPALACHIAN COAL BASIN

By Paul W. Jeran[1] and Jacqueline H. Jansky[1]

ABSTRACT

This Bureau of Mines report has been prepared to provide a means whereby mineworkers without specific geologic training can recognize and record the existence of potentially hazardous geologic features encountered in coal mines. Each geologic feature described in this report has been implicated in roof failure. Through the recording of the observations of mineworkers, based on this report, a geologic map of mine workings and the associated ground control problems can be compiled. From such maps, the trends of changes and features can be determined and projected ahead of mining. The face crew can be alerted to a potential problem and what to look for as the face is advanced.

[1]Geologist, Pittsburgh Research Center, Bureau of Mines, Pittsburgh, PA.

INTRODUCTION

Roof falls are a major cause of death and injury to underground coal miners. Aside from the human tragedy, many days of nonproductive work are used to clean up and resupport fallen roof. The Bureau of Mines, through its ground control research program, is analyzing the roof fall problem and developing techniques that will reduce the number and severity of accidents due to ground failure.

Areas of bad roof are local occurrences in the majority of coal mines. The difference between good and bad roof can usually be attributed to a change in the roof strata, provided that the mining method or technique has not been changed. Geologic evidence for this change is usually present but goes unnoticed until the situation becomes critical and sometimes is not noticed even then.

This report has been prepared to acquaint the readers with potentially hazardous geologic features that they can readily observe and record. Each of the features described in this report has been implicated in roof failures; however, no feature or change in roof strata guarantees that roof control problems will or will not occur. With time and experience, a geologic map of a mine's workings and the associated ground control problems can be compiled. From such maps, the trends of changes and features can be determined and projected ahead of mining. The face crew can be alerted to a potential problem and what to look for as the face is advanced.

This report describes a method of determining the orientation of planar features. It has sections on general rock description (lithology), features developed during deposition of strata (sedimentary features), and features that result from the rocks being deformed by geologic forces (structural features).

Illustrations are used to provide visual examples of each feature. The black and white stick used in the photographs (all from mines in the northern Appalachian Coal Basin) is a reference scale to give the viewer an idea of the size of each feature. The alternating bands on the stick are 6 in (15.2 cm) long, and the entire stick is 30 in (0.76 m) long.

ORIENTATION

Most geologic features occur in groups, i.e., where one is observed others may be expected. For this reason, it is important to record each occurrence of each feature on a suitable scale mine map. With planar features, such as bedding, clay veins, slips, and joints, the orientation of each is important.

A geologist records the attitude or orientation of any plane by two values--strike and dip (fig. 1). Strike is the direction with respect to some reference (usually north) of a horizontal line in the plane. In a flat-lying coal mine (grades less than 10 pct), the intersection of the plane and the roof is usually a reasonable approximation of a horizontal line. In figure 1 the strike is a° to the right of the reference direction (inby entries). The dip is the angle measured in the vertical plane perpendicular to the strike downward from the horizontal plane to the feature plane. In figure 1 the dip is b° downward to the right of the strike.

The symbol used to denote strike and dip on a map is shown in figure 1. The long line is drawn parallel to the strike direction with respect to the reference direction. The short line indicates the dip direction and has the dip angle written next to it. Figure 1 shows the map symbol for the illustrated strike and dip.

Geologists usually use magnetic compasses with clinometers to measure orientation. These are readily available

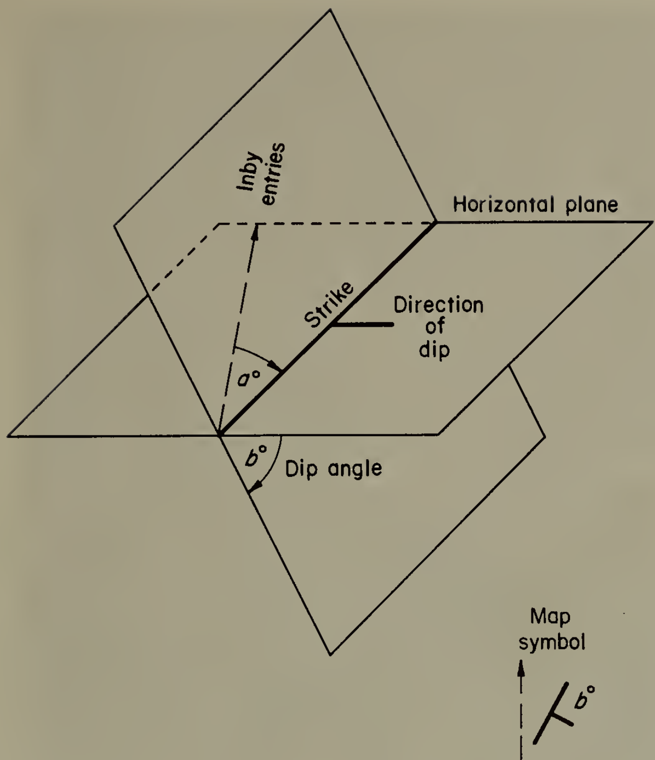

FIGURE 1. - Diagram illustrating strike and dip.

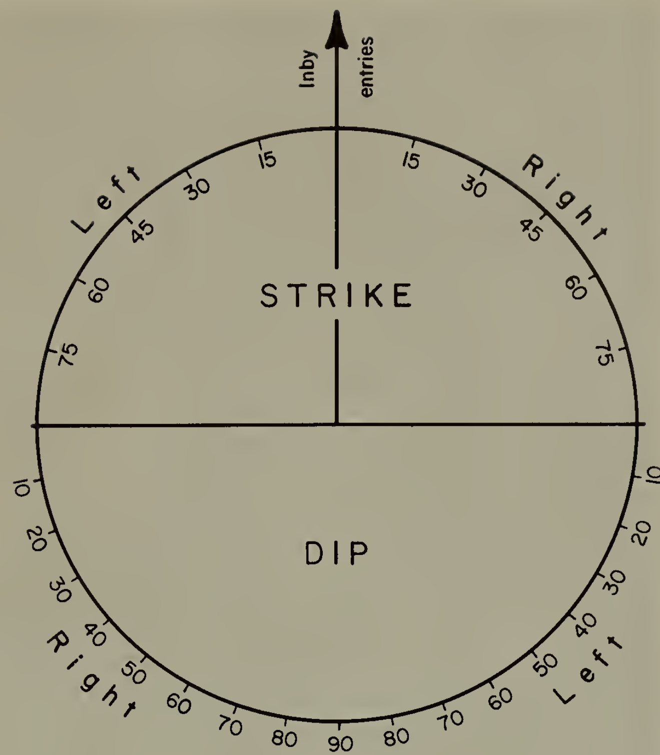

FIGURE 2. - Orientation aid.

for under $100 each, and with a little training almost anyone can use one. However, as an alternative, a simple orientation aid card (fig. 2) method is suggested for use underground.

The reference direction chosen is inby parallel with the entries. To determine the strike of a planar feature, the card user stands facing inby with the trace of the planar feature overhead. The orientation aid card is held flat in the hand and the arrow is oriented so that it points inby parallel to the entries at the location of the measurement. By using the upper half of the aid (labeled strike), the direction of the trace of the feature in the roof is estimated relative to the reference direction (fig. 3). The number of degrees left or right (strike direction) is recorded.

To estimate the dip, the card user faces, in the same direction as the strike, the trace of the feature plane in the rib (fig. 3). The orientation aid

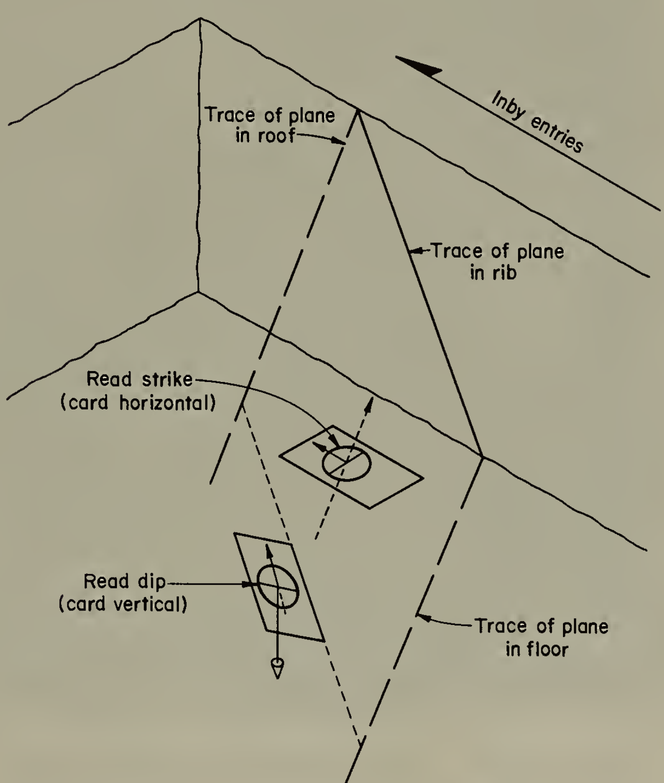

FIGURE 3. - Illustration of orientation aid use.

card is held vertically, and the left or right edge is aligned with the trace of the plane in the rib. A weighted string is held at the center of the diagram and is allowed to fall within the lower arc on the card (labeled dip). The number of degrees and their relationship (right or left) to the strike are recorded.

These data should be transcribed to the mine section map later. Maps with these data should be kept, not discarded, when the section is mined out. Consultation of these maps when mining in the vicinity of old workings will alert the crew to the features and orientations they may encounter as they advance the face.

LITHOLOGY

Within the coal mining industry there are many terms used to describe the rocks encountered in mining. While these terms have meaning within a given mine or mining area, this meaning can vary from one mine or area to another. This can lead to confusion and misunderstanding when the experience gained from one area is related to a mine in another area. Geologists use a rock classification system that describes rocks precisely. This system is too complex for general use. This section has been included to provide the readers with a basic rock classification that is compatible with the geologic classification.

Lithology is the description of rocks based on color, mineralogic composition, and grain size. In U.S. coalfields, the rocks associated with bituminous coalbeds generally fall into one of the three types of sedimentary rocks--sandstone, shale, or limestone. Sedimentary rocks are (1) the result of weathering and erosion of the preexisting rock, (2) the product of deposited organic material, or (3) the chemicals left when seawater evaporates. Thus sedimentary rocks can be classified as fragmental, biological, or chemical. The following is a brief commentary on distinguishing each of the three sedimentary rock types.

SANDSTONES

Sandstones are fragmental sedimentary rocks made of visible sand-sized grains cemented together by a filler material. Sandstones are sandy to the touch (like sandpaper). The color of sandstone ranges from a gray to red to tan. Sandstones can be identified by the visible sand grains.

Occasionally sandstones contain the mineral mica. This mineral looks like small flakes of shiny cellophane. Where mica is lying on a bedding plane, the bedding plane will appear shiny and the sandstone will tend to separate along this layer. Where observed, this should be noted as micaceous sandstone. From a distance, e.g., when looking at the top of a high roof fall from its base, a mica-covered bedding plane may appear as shiny as a slickenside but will not have the grooves or scratches. A close inspection of the rock should determine if the shiny surface is a micaceous bedding plane or a slickenside.

SHALES

Shales are also fragmental sedimentary rocks, but the grains are so small that no individual grains can be seen by the naked eye. These rocks are formed by the compaction of mud. Shales tend to break into layers and feel smooth to the touch. Usual colors are gray or black but can be tan, red, or green. Shales may be identified by their very fine grains, smoothness, ease with which they can be scratched by a piece of steel, and a tendency to break into flat pieces. When a piece of shale is scratched, the resulting powder is the same color as the rock itself. Shales associated with coalbeds may contain the imprint of fossil leaves. Bedding planes in shale can be highly reflective when wet (fig. 4). Wet bedding planes should not be mistaken for slickensides.

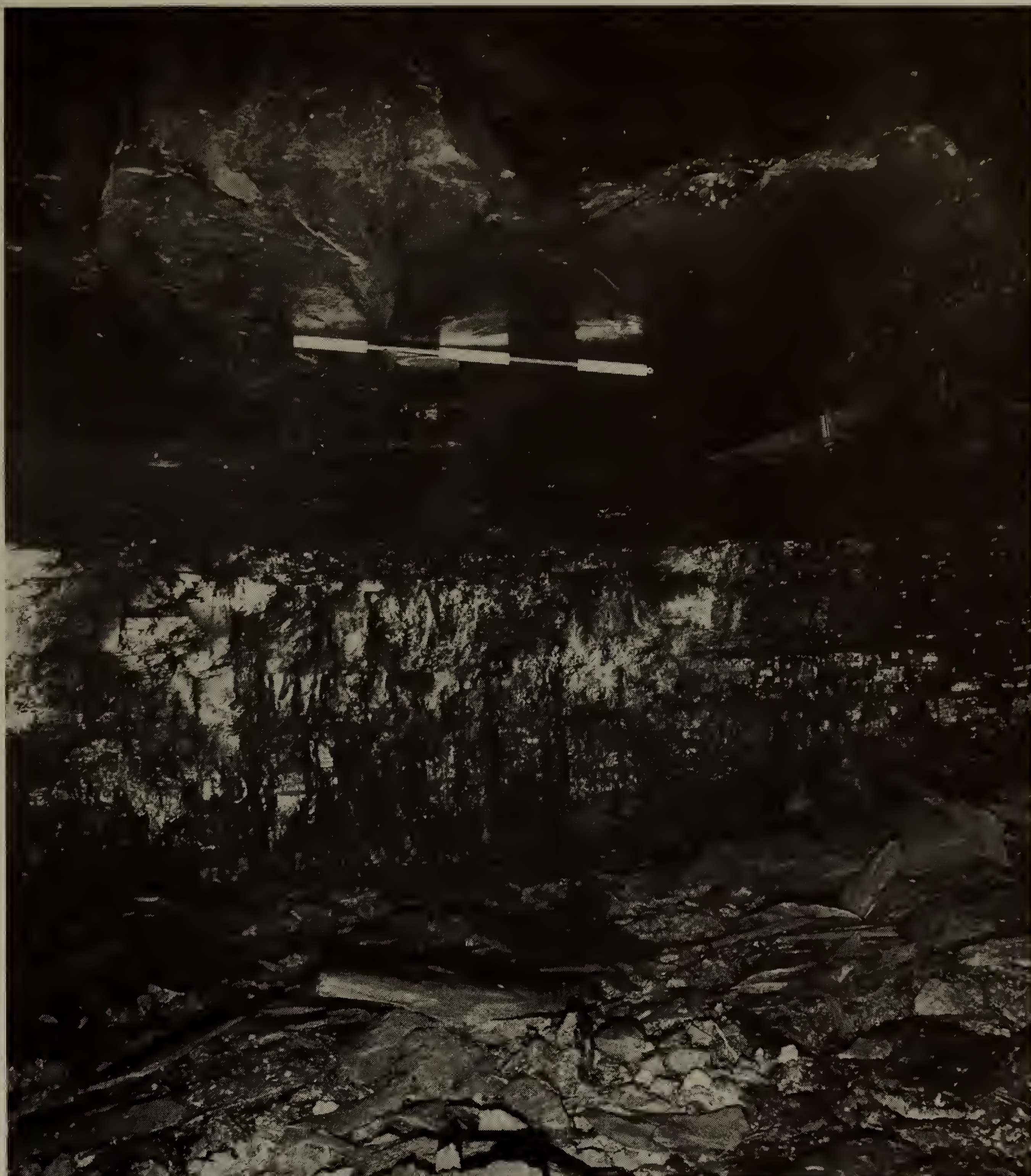

FIGURE 4. - Wet bedding plane.

LIMESTONES

Limestones are sedimentary rocks that can be fragmental, biological, and/or chemical. Limestones are made of the mineral calcite, which generally exists as small grains. They are generally massive rocks, may contain seashell fossils, and rarely break into flat slabs as does shale. Limestones are generally gray to tan in color, but when scratched, the resulting powder is light gray to white. Note that this is different from shale, which produces powder essentially the same color as the rock itself.

BEDDING

Any description of a roof problem should give at least the rock type(s) involved and their thickness. The individual layers making up the rock stratum are called bedding, and where this can be observed, the bedding thickness should be noted as well as the thickness of the rock type. There are two types of bedding that may be observed and noted. First is normal bedding (fig. 5), where the bedding parallels the coalbed. Second is crossbedding (fig. 6), where the bedding is other than parallel with the coalbed.

Categorization of a rock layer as crossbedding should be done carefully. To be considered crossbedding, all the bedding must be inclined to the coalbed. If only one or two surfaces are inclined and the balance of the bedding is parallel to the coalbed, a group of slickensided surfaces has been encountered, not bedding.

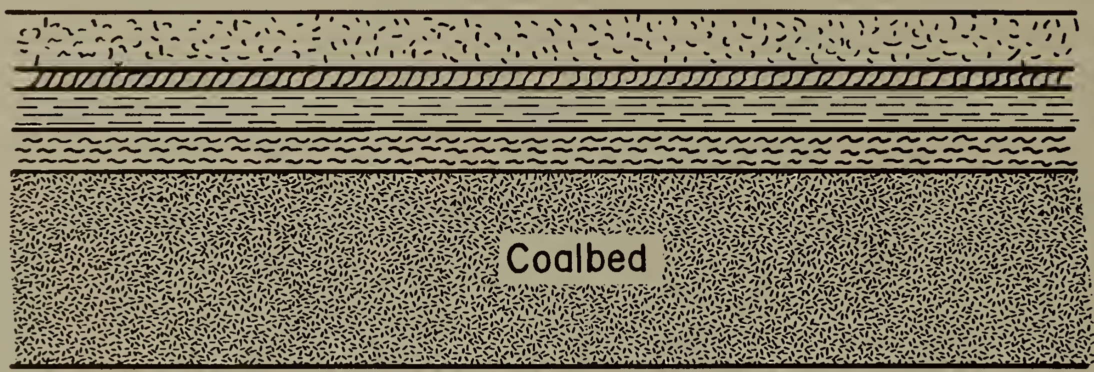

FIGURE 5. - Normal bedding.

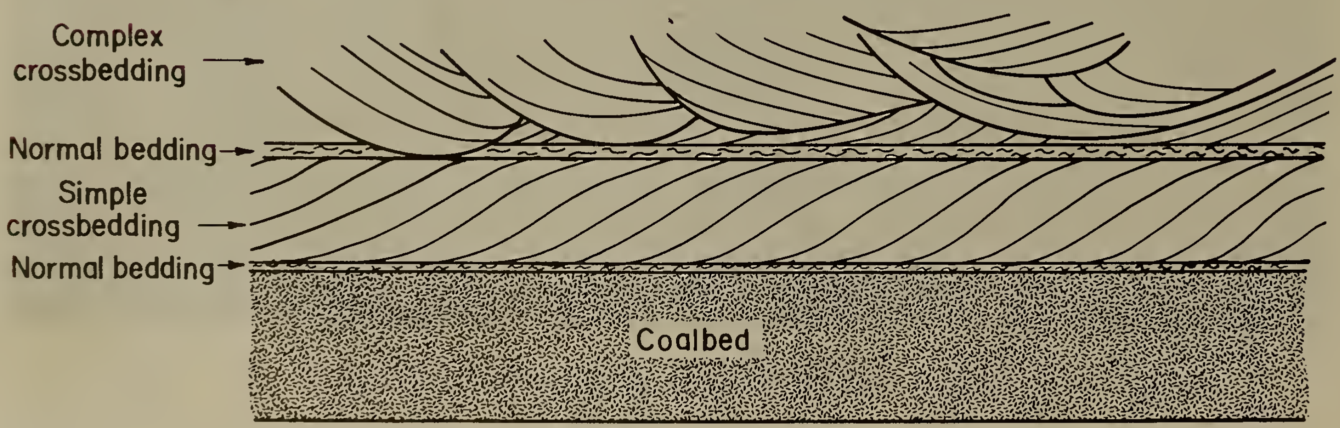

FIGURE 6. - Crossbedding.

Geologists use the term "facies change" to describe the lateral change of rock types. When the immediate and/or main roof rock changes types within a distance of 200 ft (61 m) or less, then problems might be expected. Where observed, this should be noted on the mine map. Roof bolting machine operators can be very helpful by noting, during drilling, where and when such changes occur.

SEDIMENTARY FEATURES

One particular rock feature is the sandstone channel. This feature may affect only the roof, or may partially or wholly cut out the coalbed. Where the coalbed has been cut out, the usual descriptive terms used by miners are "want," "wash out," "pinch out," or "fault." Where the coal is thinned by rock protruding from the roof, the feature is commonly called a "roll" or "pinch out." Where these can be traced to a sandstone bed or channel, they should be called a sandstone channel. Since "fault" is a specific structural feature, this term should never be applied to a sandstone channel. Details to be noted on a mine map are (1) the trend of the sandstone channel, (2) the width of the feature measured at the top of the coalbed, and (3) the thickness of coal remaining in place.

Sandstone channels can be observed in two distinct occurrences. First is the true cutout where the individual layers of coal are cut by the sandstone (figs. 7-8). Note that the layers of coal terminate at the sandstone and there is little change in coal thickness as mining approaches the channel. The second occurrence is where the sandstone has been pushed into the coalbed, causing the coal to be squeezed out to either side of the sandstone channel (fig. 9). The layers of coal are bent downward, which may show some wrinkling, and the coalbed may double in thickness on either or both sides of the sandstone. Slickensided surfaces are common.

Another lithologic feature is the kettlebottom. This feature is also called "caldron bottom," "pot bottom," or "coal pipe." It is the mud cast of a fossil trunk or root of a tree or fern, which extends upward into the roof rock above a coalbed. It is commonly surrounded by a thin layer of coal and/or slickensides. This feature may fall at any time without warning. Where kettlebottoms are commonly found, roof control plans contain specific methods of supporting or taking them down. Figure 10 shows a supported kettlebottom in place. Figure 11 shows a kettlebottom with the rock around it having sloughed off; the shape of the bark of the original tree can be seen. Figure 12 shows the void left by a kettlebottom that has fallen.

Kettlebottoms are usually found in groups. The location and diameter of each kettlebottom should be noted on the mine map. If a kettlebottom has fallen out, the thickness of the fallen piece should also be recorded.

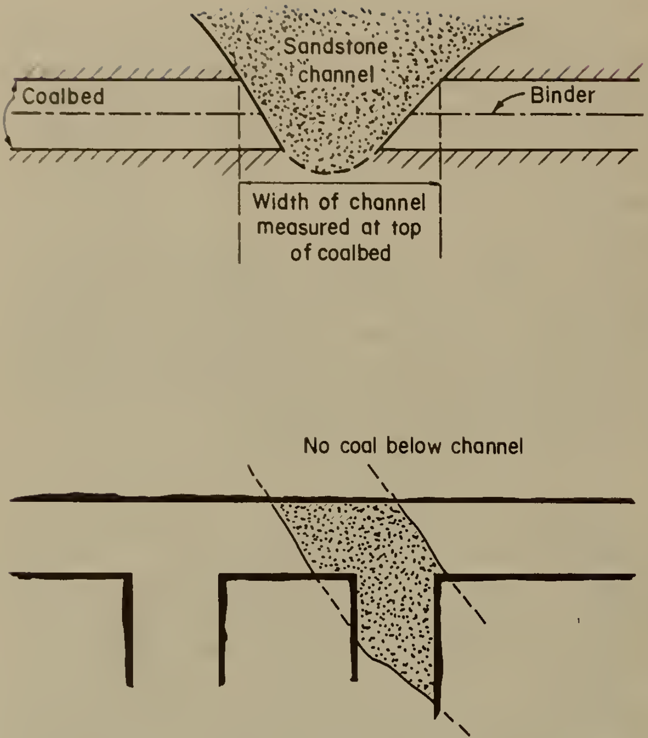

FIGURE 7. - Sandstone channel cutting out coalbed.

FIGURE 8. - Sandstone channel with coal layers terminating against sandstone.

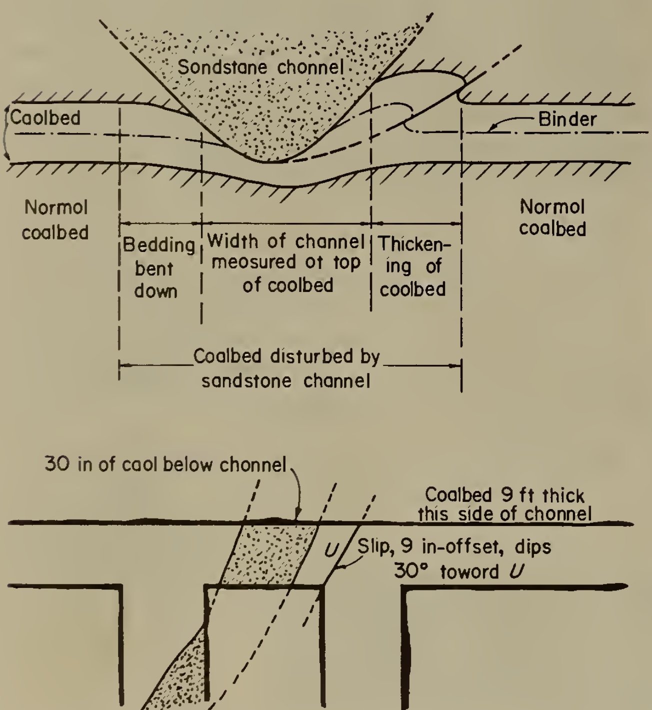

FIGURE 9. - Sandstone channel with coal layers deformed next to sandstone.

FIGURE 10. - Supported kettlebottom.

FIGURE 11. - Kettlebottom with surrounding roof rock sloughed.

FIGURE 12. - Void left by fallen kettlebottom.

STRUCTURAL FEATURES

When sufficient stresses are applied to rock strata, the strata will either bend or break. Where rock strata are bent, geologists use the term fold. Folds are usually described as either anticlines, where the beds form an arch, or synclines, where the beds form a trough (fig. 13). Occasionally, minor folds may be observed in the working place. These usually result from the local movement of the coal or associated rocks past each other. The major folds found in coal basins are generally so broad that an entire mine would lie within only a small portion of one.

Breaks in the rock strata are easily observed. The geologist uses the general term "fracture" to describe all breaks or cracks. All fractures should be noted, particularly their orientation, length, and the distance between fractures having the same or similar orientations. Sometimes the fractures have deposits in them, and this should be noted (fig. 14).

There are several types of fractures that have been given specific names because of their shape. The most common of these is the joint. Joints are reasonably straight and smooth cracks in rock along which there has been no movement. Soft-coal miners are generally familiar with cleat in coal. Cleat in coal is the same as joint in rock. Where a crack or group of cracks that look like coal cleat is found in the roof or floor rock, the term "joint" is used to describe them. Figure 15 shows joints in roof rocks; some material is in place, and some is partially fallen.

Generally speaking, the cleats and joints within a mine are consistent in orientation or spacing. To verify this, they should be measured at intervals [about every 500 ft (152 m)]. Should any change be found in either orientation or spacing, it should be noted and recorded on the mine map. Experience has shown that such changes are indicators of local geologic disturbance and potential mining problems.

Where there has been movement of the rock or coal along a fracture, the result may be a slickensided surface. Movement of less than 1 in (2.54 cm) can create a slickensided surface. These surfaces are generally polished with either scratches or grooves all in one direction (fig. 16). Small slickensided surfaces are usually curved (fig. 17), while larger ones tend to be fairly planar (fig. 18). The orientation of these surfaces should be measured and also the direction of last movement. The direction of last movement can be determined by rubbing the surface in the same direction as the grooves or scratches. One direction will feel smoother than the other. This smoother direction is the direction in which the missing block of rock last moved relative to the rock surface being rubbed.

For practical purposes, three terms may be used to describe a fracture where the rocks and/or coal have moved--slickenside, slip, and fault. Slickenside should be used where a slickensided surface is observed but the amount of movement cannot be determined. Slip should be used where the feature is confined to three or fewer entries. Fault should be used where the feature can be traced across a section or several entries. In general, slips will exhibit smaller movement than faults.

The description of a slip should include its orientation, the direction of last movement, the amount of offset, and the length it can be traced across the mine workings. If only a small portion [about 1 ft^2 (0.29 m^2)] of slip is observed, then it would be better to call this a slickenside.

The description of faults is more complex. The orientation of the fault and the direction and amount of movement must be measured and recorded. Faults may occur with one or more planes of movement and with relative movements in opposite directions. Where more than one plane of movement is present, the proper term is

FIGURE 13. - Anticline and syncline.

FIGURE 14. - Mud-filled fractures in roof, sometimes called hill slips.

FIGURE 15. - Joints in roof rock.

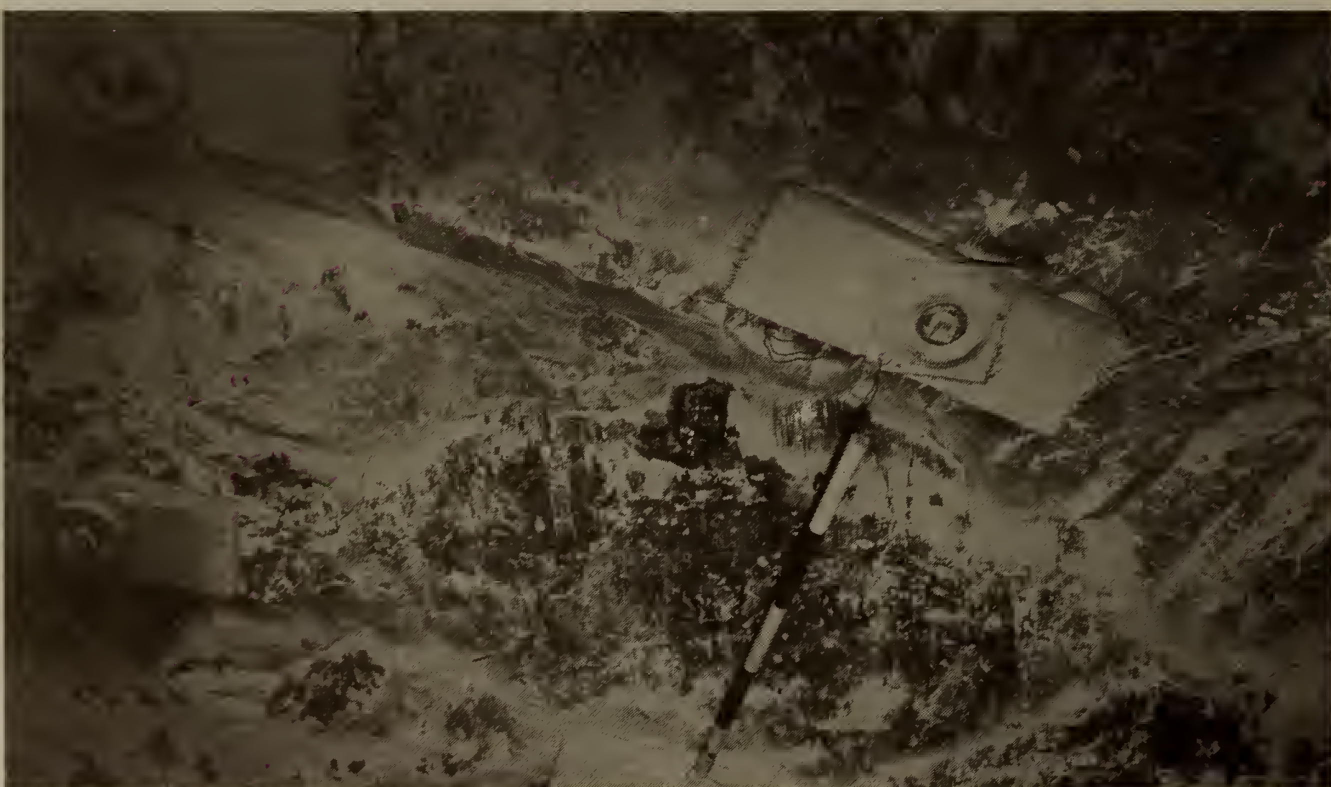

FIGURE 16. - Slickenside showing polishing and grooving.

FIGURE 17. - Slickenside showing curved surface.

FIGURE 18. - Slickenside showing planar surface.

fault zone (fig. 19). The width of the fault zone should be measured and its orientation estimated. The offset of the strata on either side of the zone should be measured or estimated.

Faults may dip at any angle from perpendicular to parallel to bedding. At the two extremes it is necessary to record direction of last movement or the direction of the scratches or grooves in the slickensided surfaces of the fault planes.

Larger faults may not exhibit slickensides but may have a zone of ground material in them. This material comes from the rocks and coals adjacent to the fault that were crushed when the movement took place along the fault. If present, this material should be noted and its thickness measured and recorded.

When recording faults on the mine map, solid lines should be used only where the fault crosses entries and has been observed. Dotted or dashed lines can be used where it crosses pillars or barriers. Except for faults that parallel the bedding, all faults have one side that is higher than the other. This should be noted on the mine map by placing a U (for up side) on the side of the fault that is higher or a D (for down side) on the side of the fault that is lower. The dip of the fault plane can then be recorded as toward the high or low side.

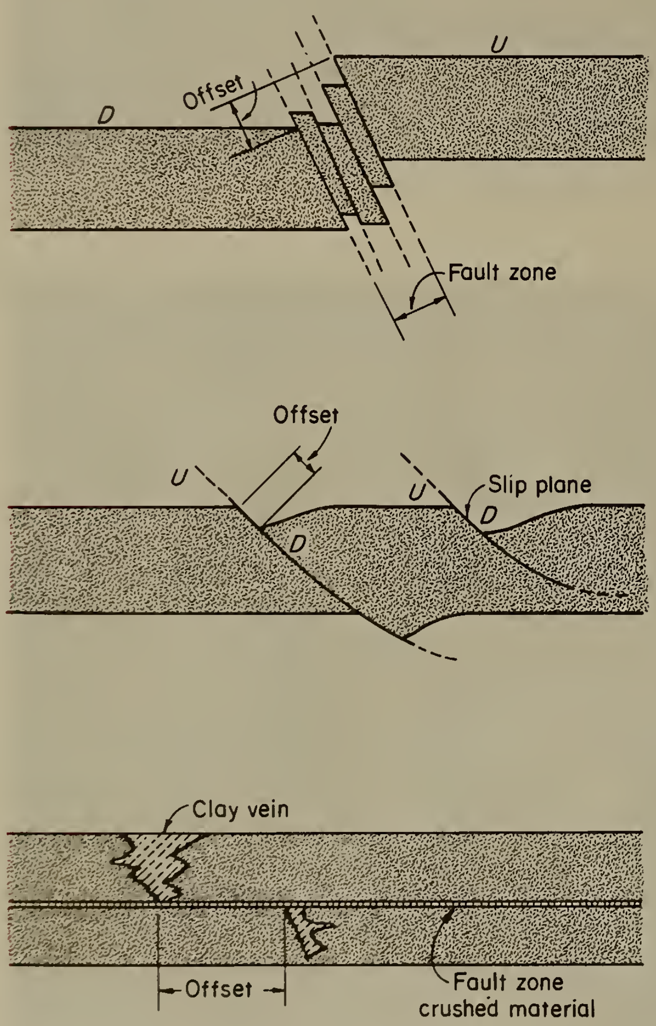

FIGURE 19. - Faults.

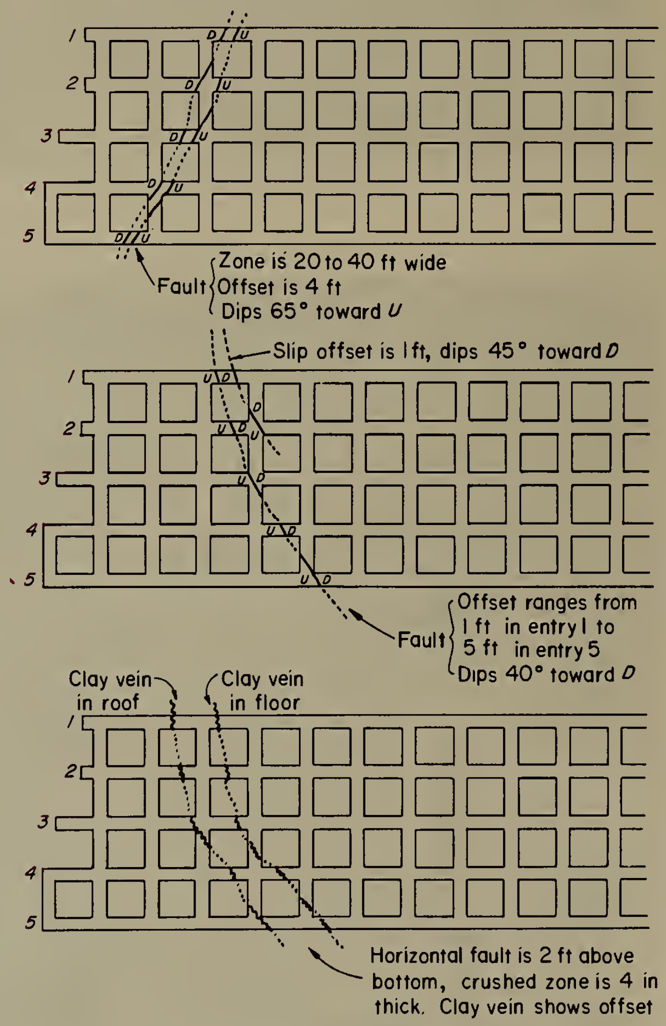

FIGURE 20. - Faults recorded on a section map. Note faults rarely are perfectly straight.

The fault sketches in figure 19 are exposures in the outside rib of entry No. 1 of figure 20, which illustrates each of these faults as they might be recorded on a map of the section.

CLAY VEINS AND MUD-FILLED FRACTURES

Clay veins and mud-filled fractures are found in several of the northern Appalachian coalbeds. Increased methane emissions and water inflows have been reported when these features are first penetrated by mining. Where these features penetrate the coalbed from above, unstable roof commonly occurs. Miners usually call any rock-filled fracture a "clay vein" or "spar." These two features differ markedly in shape and should be recorded separately. The clay vein (fig. 21) is typically "Christmas tree" shaped with the coal-rock contact being interfingered. The mud-filled fracture (fig. 22) is usually planar with the coal-rock contact relatively smooth. Where the two features occur together, they should be measured and recorded separately.

To describe either feature, its orientation and thickness should be measured. The length of penetration into the coalbed should be noted [for example, clay vein from roof 36 in (0.9 m) into 48-in (1.2-m) thick coalbed, strike 30° right, dip 80° left, tapers from 12 in (0.3 m) wide at roof line to zero].

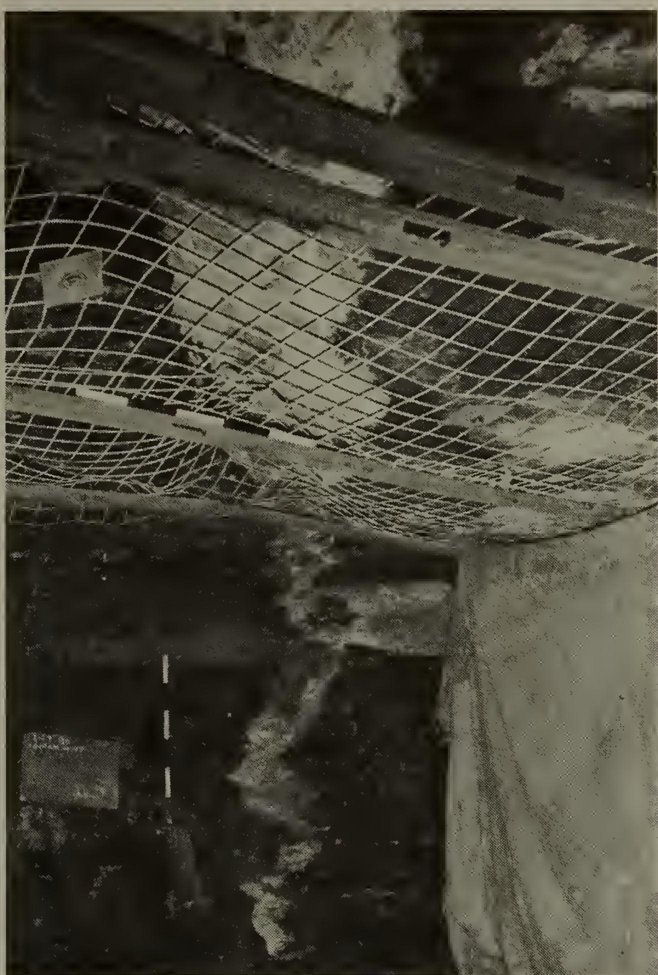

FIGURE 21. - Clay vein.

FIGURE 22. - Mud-filled fracture transecting coalbed.

SUMMARY

This report has been prepared to give a nongeologist a means of recognizing, describing, and recording potentially hazardous geologic features commonly encountered in underground coal mining. The major geologic features present in coal mines in the northern Appalachian Coal Basin that may pose ground control hazards during mining are illustrated. The report cannot possibly cover all geologic features. If the user finds a feature that is not covered in this report, he or she should describe and record what is seen in as simple words as possible. Very often a simple sketch with the written description can be very helpful in conveying to others what was observed.

Most mines have encountered one or more of the illustrated features and have, with varying degrees of success, mined through them. No records are usually kept when changes have been made in mining method and/or roof support to cope with such hazards. Then when similar problems are encountered several years later, the whole process of finding a solution must be repeated.

If remedial methods are recorded along with the geologic features on mine maps, then, over the course of a mine's life, these maps may be consulted as similar features are encountered, and what did not work in the past can be avoided. As sufficient data are gathered, the mining method and roof support can be tailored to meet specific local conditions, thereby saving both time and money while safely and efficiently mining the coal. In addition, the use of standard terminology will allow the transfer of mining experience from one area to another with respect to specific features.

BIBLIOGRAPHY

1. Bates, R. L., and J. A. Jackson. Glossary of Geology, 2d ed. 1980, 749 pp.

2. Cox, R. M. Why Some Bolted Mine Roofs Fail. Trans. AIME, v. 256, 1974, pp. 167-171.

3. Headlee, A. J. W. Fracture Zones in Mine Strata. Min. Cong. J., v. 30, No. 4, April 1944, pp. 57-60.

4. Kearns, E. G., Jr. Clay Dikes in the Pittsburgh Coal of Southwestern Greene County, Pennsylvania. M.S. Thesis, WV Univ., Morgantown, WV, 1970, 50 pp.

5. Kent, B. H. Geologic Causes and Possible Prevention of Roof Fall in Room-and-Pillar Coal Mines. Pennsylvania Geological Survey, 4th Ser, Inf. Circ. 75, 1974, 17 pp.

6. Lahee, F. H. Field Geology. McGraw-Hill Book Co., Inc., New York, 5th ed., 1952, 883 pp.

7. McCabe, K. W., and W. Pascoe. Sandstone Channels: Their Influence on Roof Control in Coal Mines. MSHA IR 1096, 1978, 24 pp.

8. Stahl, R. L. Guide to Geologic Features Affecting Coal Mine Roof. MSHA IR 1101, 1979, 18 pp.

9. Thrush, Paul W. (comp. and ed. by). A Dictionary of Mining, Mineral, and Related Terms. BuMines SP 2-68, 1968, 1269 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1983-605-015/09

INT.-BU.OF MINES,PGH.,PA. 26625